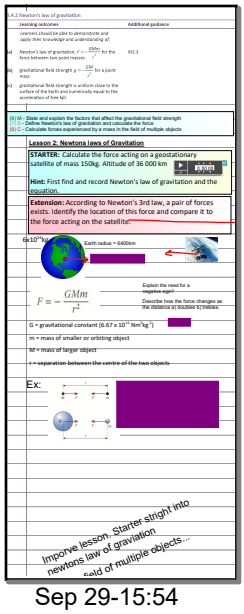

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(6) M - State and explain the factors that affect the gravitational field strength
(7) S - Define Newton's law of gravitation and calculate the force
(8) C - Calculate forces experienced by a mass in the field of multiple objects

Using Newtons law of gravitation:

$$F = -\frac{GMm}{r^2}$$

$g = \frac{F}{m}$

$g = -\frac{GM}{r^2}$

Derive an expression for the gravitational field strength by using 'Newton's law of gravitation'

When would you use this equation compared to the equation from last lesson for 'g'?

Ex: Show that the unit is equivalent to ms^{-1}

Answer:

g = F/m is for uniform field.

$g=GM/r^2$ is for a radial field

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Support sheet

Worked examples

Example 1: Use of equation at surface and above surface of the Earth

The Earth can be assumed to be a uniform sphere of radius 6.4×10^6 m and have a mass of 6.0×10^{24} kg. Calculate the gravitational field strength g:

a on the surface of the Earth

b at a height of 3.2×10^6 m above the surface of the Earth.

$M = 6.0 \times 10^{24}$ kg $\quad r = 6.4 \times 10^6$ m

a *Step 1 Substitute values in equation* $g = \frac{GM}{r^2}$

$$= \frac{6.7 \times 10^{-11} \times 6.0 \times 10^{24}}{(6.4 \times 10^6)^2}$$

$= 9.81$ N kg^{-1} or m s^{-2}

b *Step 2 Assume all of the mass is concentrated at the centre.*

At a height of 3.2×10^6 above the surface, the radius

$r = (6.4 + 3.2) \times 10^6 = 9.6 \times 10^6$ m

Step 3 Substitute values into equation $g = \frac{GM}{r^2} = \frac{6.7 \times 10^{-11} \times 6.0 \times 10^{24}}{(9.6 \times 10^6)^2}$

$= 4.36$ N kg^{-1} or m s^{-2}

One misconception of many students is that 'there is no gravity in space' whereas in actual fact the gravitational field strength is only zero when two gravitational field strengths are equal and cancel as in the next example.

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Mount Everest is approximately 9.0 km high. Calculate how much less a mountaineer of mass 100 kg (including backpack) would weigh at its summit, compared to her weight at sea level. Would this difference be measurable with bathroom scales?

Hint

Answer

2.8 N (or 0.3 kg on scales). Measurable with bathroom scales, though hard to achieve accuracy.

	Mass/kg	Radius/km	Distance from Earth/km
	Mass		
Earth	6.0×10^{24}	6400	–
Moon	7.4×10^{22}	1740	3.8×10^5
Sun	2.0×10^{30}	700 000	1.5×10^8

6 Jupiter's mass is 320 times that of the Earth and its radius is 11.2 times the Earth's. The Earth's surface gravitational field strength is 9.81 N kg^{-1}. Calculate the gravitational field strength close to the surface of Jupiter.

Answer

25.0 N kg^{-1}

Plenary 1 and

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